Computer-induced changes in intellectual and scientific work

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1. General theoretical considerations

Writers working on short stories or novels, journalists producing newspaper columns, scientists elaborating papers, preachers preparing sermons, - they all do "intellectual work" in the sense of creating, gathering and synthesizing verbal information in order to generate relatively complex wholes of explicit verbal communication.

By doing this, they all exploit three fundamentally different sources of information:
1) *Intrapersonal sources* (e.g. physical memory or the content of their diaries or notes)
2) *Interpersonal sources* (e.g. bilateral communication with colleagues or multilateral team or workshop discussions)
3) *Institutional sources* (e.g. published books, journals or official documents like law books or statistical manuals)

While modern literary production is characterized by high reliance on intrapersonal subjectivity, scientific work is supposed to be guided by interpersonal communication networks within professional disciplines as well as by systems of worldwide institutional publication.
In the legal field, institutional sources (like statutes or court decisions) are supposed to prevail.

In the following, it is argued that the computer generates the basis for fundamental changes in the way these three axes of intellectual activity are functioning and the way they are interrelated to each other.

Three basic aspects of functional changes can be identified:

1) Externality: the operation of all functions (like storage, reordering, selective retrieval etc.) is highly independent of physical and psychological contingences of the individual actors involved.

2) Complexity: the amount and variety of operated informational materials as well as the number and sophistication of applied manipulation procedures is extremely high and seems to be increasing without theoretical limits.

3) Controllability: compared to all other informational technologies, individual actors have more autonomy in choosing when, where, in what way and for what purpose they want to make use of any available informational procedures.

2. Self-related functions

When the history of microelectronic technology is written one day, it will be found remarkable that small computer sets began their career as stand-alone "personal computers" designed primarily for supporting (=complementing and/or substituting) individual mental (particularly memory) functions.

1) Externality

Traditionally, any written text was likely to be expressive of the author's internal state of mind at the very moment of its production (or last revision).

The availability of externalized computer memories makes it more likely that text producers rely directly on past writings of their own, while reliance on actual subjective memories, emotions, and accidental information declines.
This is facilitated by the fact that in contrast to traditional notes and drafts, computerized documents can be copied and transferred by automated functions, so that no effort of conscious re-reading and re-writing has to be involved.
As a consequence, texts can reach higher levels of independence from accidental and transitory subjective factors by combining and synthesizing the knowledge and the perspectives, reflections and stylistic preferences of the same individuals at very different points of biographical time.

From the perspective of the philological sciences, this means that it may become impossible to reconstruct the "intellectual history" of a monography or the whole life work of an individual thinker, because the available texts contain no hints about the time periods when certain passages were created or revised.
Externality may also facilitate reflective acts of self-evaluation and self-critique. By editing older documents, individuals meet their own "past selves" in a far more explicit and objectified sense than by simply "remembering" previous thoughts and action. As a consequence, they are better able to assess how much and in what way their thinking has changed in the meantime .

2) Complexity

Average hard disks have enough space to store all texts ever produced by even the most prolific writer. In contrast to the physical memory, all components are maintained at the same high level of accessibility and explicit precision.
As a consequence, computers enable individuals to create more complex and more differentiated "private intellectual worlds" potentially containing at any moment the accumulated stock of all earlier writings.
In other words: whenever they look for suggestions or information while writing, they are more inclined to exploit their own accumulated memory than to consult foreign texts or communicate with colleagues.
In intellectual fields where highly individualized thinking has traditionally been the rule (e.g. in philosophy), computers may therefore reinforce trends toward highly idiosyncratic individual styles.

3) Controllability

Self-control over the psychological memory system is rather limited because thoughts follow each other in a rather spontaneous, associative fashion and because most stored items suffer from obsolescence during time.
Vis-à-vis their externalized computer memory, individuals find themselves in a far more autonomous position, because they can easily evoke every item they wish with full precision at every moment of time.
As no principles of "forgetting" are operative in order to reduce the available complexity, individuals are even *forced* to make their own selections about what should be evoked or suppressed at any one moment.
Thus, computers catalyze the genesis of individualized (and highly flexible) systems of ordering information and products of intellectual work.
In addition, individuals are better able to standardize and routinize verbal expression habits or explicit thought structures by re-using the same formulations or text components on very different occasions.

3. Interpersonal functions

E-mail systems, computer conferences and other applications constitute new media of interpersonal communication, filling the gaps between flexible informal face-to-face interactions on the one hand and the rather clumsy habit of exchanging written letters on the other.

1) Externality

Computer-supported communication communication flows are extremely dissociated from all physical, behavioral and psycho-social contingencies of individual emitters and receivers.
The whole meaning of E-messages has to be inferred exclusively from their intrinsic verbal characteristics, because absolutely no nonverbal cues (like tone of voice, mimic or gestic movements etc.) are provided that would help to specify their interpretation, evaluate their credibility or to judge how much importance is attached to them by the senders.
By eliminating influences stemming from status differentials or personal assertiveness etc., computer-supported communication processes provide relatively free and equal chances of expression for all participants. (Kiesler/Siegel/McGuire 1988: 660).
Of course, the advantages of status levelling accrue particularly to incumbents of low status positions (while high ranking individuals may correlatively lose because they are no longer able to display their superior prestige). This explains the empirical finding that more electronic contacts are directed from lower to higher levels than the other way round. (Welsh 1982).
Evidently, E-communication is most adequate in cases where words have a highly standardized and consensual meaning, so that there is no need to provide additional specifying cues. Thus, it will be used widely in scientific fields characterized by high paradigmatic development and formalized codes of expression (mathematics, chemistry etc.) and less in most social sciences or humanities, where imprecise definitions and nonconsensual terminological interpretations prevail.

2) Complexity

By combining the informality and interactive flexibility of telephone conversations with the high transmission capacity and precision of mailed documents, computer networks can carry communication processes higher in variety and complexity than any of the conventional translocal technology alone.
Thus, it is possible to contact many different interaction partners very quickly (or almost simultaneously in multilateral arrangements), to engage in regular or even continuous processes of interaction and to transport very complex packages of information (e.g. integral data sets or manuscripts) within a very short time.
As a consequence, intellectuals are likely to draw their knowledge or ideas from a larger absolute number of other individuals (Huber 1990; Foster/Flynn 1984) and to confront themselves with a more heterogeneous variety of different points of view.
Thus, they tend to see highly divergent opinions or little paradigmatic consensus within their specific scientific fields. (Kerr/Hiltz 1982: 99ff.).
In general, the capacity of e-communication to increase complexity and divergence seems to be much higher than to generate consensus and eliminating deviant opinions, because the lack of nonverbal levels of communication makes it difficult to exert leadership and because different participants can send and receive different messages at the same time. Thus, an acentric web-like structure of multiple coexisting threads of conversation is likely to emerge: contrasting with the focussed "chain-structure" in conventional face-to-face discussions. (Kerr/Hiltz 1982: 143).
Therefore, E-communication is particularly useful when the main goal is to maximize the richness and heterogeneity of expressed views and opinions or conveyed information (e.g. for brainstorming or the "Delphi-Method") (Martino 1972).

Countervailing the growing complexity of *translocal* communication, the complexity of *local* communication systems can be decreased. For instance, it is no longer necessary to incorporate into a residential research team all the kinds of qualifications ever required, because any translocal informants can be contacted whenever a need for highly specific information or advice arises. (Strassman 1985).
This again may increase the flexibility of research units and their capacity to reach quick and consensual decisions (Huber 1990).

3) Controllability

Conventional forms of communicative interaction imply considerable restrictions of autonomy, because individuals have to be present at certain places for specific periods of time.
Computer networks give rise to a new type of communicative participation role, outstanding for its almost complete lack of interference with all other kinds of individual roles and activities.
Irrespective of their geographical location and many other situational contingencies, individuals can chose any time to send any messages to anybody - as well as deciding themselves when to read incoming messages.
The almost limitless compatibility of electronic communication behavior with various personal characteristics, roles and situational conditions is also anchored in the fact that anonymity encourages a highly informal communicative behavior contrasting sharply with the ritualistic formality of written letters. (Kiesler/Siegel/McGuire 1988).
As a consequence, prevalence, intensity and kind of communicative participation are highly dependent variables: determined almost completely by subjective needs and motivations or situational antecedent factors. (Johansen/DeGrassse/Wilson 1978). Therefore, computer conferences often suffer from "lack of discipline" caused by unpredictable changes in the intensity and quality of communicative dispositions and motivations (Kerr/Hiltz 1982: 144).

4. Institutional functions

On a third level, intellectual work may experience radical change when computers are linked to libraries, data banks and other institutions in order to provide access to publications, legal documents, statistical data and other kinds of "formal" information.

1) Externality

Externalized storage is the common characteristic of all written information. But in the traditional world of published books and journals, externalization remains incomplete because texts are still primarily segmented according to author- or editorship.
This "author-bias" again gives rise to systems of intellectual or scientific reputation where *whole individuals* are the targets of prestige attribution - an important basis for motivating intellectual producers and for structuring intellectual careers. (Luhmann 1968).
While computerized libraries still order their entries according to authorship, this *production-oriented* criterion of text-segmentation is likely to get de-emphasized or neutralized by cross-cutting *reception-oriented* selection criteria chosen by the different users.
As a consequence, the probabilities of being noticed in the intellectual world are decisively reshuffled. Even very modest authors can easily get attention when they have expressed something exactly to the point, while most prestigious scholars may be ignored without mercy when nothing relevant is found in their contributions.
intellectuals and scientists may well become faceless, anonymous contributors who have to be satisfied to be widely "used" without hope that this adds up to a considerable individual reputation.

This is most vividly seen in the case of *expert systems* which belong to the most collectivized products of human intellectuality, because originators of specific knowledge items and decision rules can no longer be identified at all.

2) Complexity

In traditional intellectual work, the richness of available information was heavily reduced by "natural" obstacles of accessibility: e.g. because less famous journals or books were not readily at hand.
In computerized libraries, all documents are retrievable on the same plane of accessibility, so that search procedures are likely to produce very heterogeneous materials from all kinds of (even quite unexpected) sources and locations. Therefore, markets of intellectual exchange become more "unbiased" because local "citation subcultures" are likely to vanish in favor of more homogeneous cosmopolitan cultures (Malone/Yates/Benjamin 1988).
Thus, scientists are likely to find that the "paradigmatic consensus" they counted on does not really exist, and judges and lawyers using encompassing legal data banks may well become quite confused because when asking a specific question, they encounter not only official statutes or highest court decisions, but also additional (otherwise ignored) sources of "valid law" (e.g. older sources of non-codified rules and practices, academic opinions etc.) (Endrös 1987:110; Raden 1989).This means that additional criteria for defining priorities among different sources of law have to be applied.
Because all primary sources are easily accessible, secondary and tertiary literature (e.g. digestions) loses much of its traditional importance (Endrös 1987: 109f.).
Electronic data banks may stifle innovative problem-solving insofar as they make it more likely that a *past solution* to any actual problem is found.
On the most general level, computers increase the operative relevance of accumulated cultural patterns by making them easily available for carrying out any concrete tasks and for solving any specific everyday problems.
On the other hand, computerized information systems may facilitate rapid cultural change because update knowledge can be made available to all users within very short time. But this increase in cultural diffusion may also contribute to a decline of individual creativity and innovativeness because, it makes it more probable that authors find (and have to accept) already existing solutions.

3) Controllability

The growing autonomy of readers is a consistent trend of cultural evolution. While papyrus rolls enforce a rigid following of successive lines, books and newspapers can be opened at any chosen page (Bolter 1984:137;161).
Computer-supported storage systems provide at least the potential to skip through immense text material for any purposes in a very short time, so that strategies of decoding are no longer determined by encoding structures at all.
As a consequence, reading behavior can become extremely individualized in the sense that every individual acquires a highly idiosyncratic combination of ideas and information mirroring his/her specific subjective needs.

This has three most important implications:

a) Influences of writers on readers decline because writers have to get along with the condition that readers don't follow their course of argumentation and that their products are decomposed and combined with other texts in unforeseeable ways.

b) Among readers, traditional mechanisms creating homogeneity and consensus (e.g. by reading the same outstanding book or journal) are no longer effective. Instead, readers individualize their knowledge background to the extent that they may find themselves isolated because they are no longer able to find topics for common discussion.

5. Increased permeability of the three spheres

Up to the present, the three levels of intellectual activities were quite separate worlds because self-related processes were centered in subjective consciousness, interpersonal exchanges in oral communication and institutional activities in fixed written documents.
Information transfer between spheres was quite difficult and highly selective because burdensome transcoding activities (e.g. writing up thoughts, protocolling discussions, presenting papers at conferences etc.) had to be undertaken.
By contrast, each personal computer can function as a device where these three worlds can meet, interpenetrate or even merge without recoding effort or loss of information.
For instance, "private notes" on hard disks can easily be turned into communication messages without changing form and content (or the other way round), while excerpts received from data banks can be assimilated into the externalized private memory or fed into computer conferences.
Individual producers can make their private intellectual world and creative processes much more transparent by communicating not only "finished" papers, but any kind of preliminary and transitional drafts or notes. By doing this, they open themselves to foreign ideas and criticism in stages where they are still quite receptive to assimilate them into their own work - not at a time when they have to "defend" their writing because it is already published in an unchangeable form.
An important consequence of this is that, in comparison with face-to-face interaction, communicative processes are less dominated by ideas which participants have actually in their minds or readily "at hand", because they are able to edit and transport stored text components created anytime in the past. (Kerr/Hiltz 1982: 126).

It is also possible to make institutional data banks "interactive" by allowing users to comment on a paper and letting authors reply. (Folk 1977:78f.). All subsequent users would then also receive all previous discussion statements - and may well feel motivated to add their own. The immutability characterizing all conventional publications can be eliminated by keeping data bank documents linked to their authors: giving them the continuous possibility to modify or extend their contributions in order to keep them up-to-date with advancing knowledge. So it may no longer be necessary to publish additional small papers whenever a minor new result has been achieved, because it is far more efficient to update existing (more encompassing) contributions.
Finally, a major procedure not available in conventional publication systems is *deletion:* allowing reduction of "scientific garbage" by eliminating once and for all outdated and misleading contributions.
Such "cleaning procedures" are additionally facilitated by the fact that "superfluous" entries (used by nobody) can easily be identified.
On the most general level, this all means that the computer causes the three spheres to become more *differentiated* and more *integrated* (or better: interpenetrated) at the same time.

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